Western University - Faculty of Engineering Department of Civil and Environmental Engineering

<u>CEE 4420A – Data science for civil engineers: geotechnical applications (With CEE 9730)-</u> <u>Course Outline 2023</u>

The objective of the course is for students to develop a hands-on understanding of the field of data science, with a focus on opportunities and more importantly limitations pertaining to applications in geotechnical engineering. Students will work in groups on two projects over the course of the term, which will be scoped with guidance from the course instructor. The projects will be peer-assessed by other groups, who will grade each other on a) legibility and quality of code and dataset as well as corresponding documentation; b) a presentation on the construction of the dataset and performance of the algorithm. Topics include:

- Introduction to Python programming and the Numpy, scikit-learn, and PyTorch packages
- Learning algorithms, unsupervised algorithms, feature engineering
- Various flavours of deep learning, and generative adversarial networks.

Each topic will be introduced alongside recent research in the field of geotechnical engineering where possible.

Calendar Copy:

Application of Python programming, learning algorithms, unsupervised algorithms, feature engineering, deep learning and generative adversarial networks in geotechnical engineering.

Prerequisites:

2219A/B COMPUTATIONAL TOOLS FOR CIVIL ENGINEERS

Antirequisites:

None

Note: It is the student's responsibility to ensure that all Prerequisite and Corequisite conditions are met or that special permission to waive these requirements has been granted by the Faculty. It is also the student's responsibility to ensure that they have not taken a course listed as an Antirequisite. The student may be dropped from the course or not given credit for the course towards their degree if they violate the Prerequisite, Corequisite or Antirequisite conditions.

Contact Hours:

2 lecture hours/week (required);
2 tutorial hours/week;
Tutorials are not mandatory but students seeking assistance with projects or clarification on lecture material are strongly encouraged to attend.
Additional self-study: 4 hours/week.

Key Sessional Dates:

Classes begin: September 11, 2023 Fall Reading Week: October 30 – November 3, 2023; Classes end: December 8, 2023;

Contingency plan for an in-person class pivoting to 100% online learning

In the event of a COVID-19 resurgence during the course that necessitates the course delivery moving away from face-toface interaction, affected course content will be delivered entirely online, either synchronously (i.e., at the times indicated in the timetable) or asynchronously (e.g., posted on OWL for students to view at their convenience). The grading scheme will **not** change. Any remaining assessments will also be conducted online as determined by the course instructor.

Instructor:

Course instructor: Bing Li Email address: bing.li@uwo.ca Office: SEB 3010C Office hours: After tutorials

CEE Office: SEB 3005 civil@uwo.ca

Textbook:

Other References:

Neural Networks and Deep Learning by Michael Nielsen *The Hundred-Page Machine Learning Book* by Andriy Burkov <u>https://towardsdatascience.com</u> is an excellent general resource The International Society for Soil Mechanics and Geotechnical Engineering maintains an excellent archive of active research in this area (<u>http://140.112.12.21/issmge/ml_ref.htm</u>)

Students are responsible for checking the course OWL site (http://owl.uwo.ca) on a regular basis for news and updates. This is the primary method by which information will be disseminated to all students in the class.

All course material will be posted to OWL: http://owl.uwo.ca.

If students need assistance with the course OWL site, they can seek support on the OWL Help page. Alternatively, they can contact the Western Technology Services Helpdesk. They can be contacted by phone at 519-661-3800 or ext. 83800.

<u>Units:</u>

Both SI and FPS unit systems may be used in lectures, tutorials and examinations.

Specific Learning Objectives:

The lectures and tutorial assignments will prepare students to do the following [GA Indicator]:

- 1. Apply Python programming language for reading in, processing, and plotting large datasets [ET 2]
- 2. Identify and format appropriate input and output formats for a range of machine learning models [PA 1, PA 2]
- 3. Identify and implement appropriate machine learning models (decision trees, support vector machines, deep neural networks) for a given engineering problem [I 1]
- 4. Understand and differentiate between various buzzwords such as machine learning, data science, big data, artificial intelligence, etc. [KB 3]
- 5. Understand and critique limitations of various machine learning models [I 3, LL 1]
- 6. Work in teams to tackle geotechnical engineering datasets from data science perspective [ITW 1, ITW 2, ITW 3]
- 7. Prepare, critique, present and document code and report on details and performance of machine learning models. [CS 1, CS 2, CS 3]

The instructor may expand or revise material presented in the course as appropriate.

TOPICS

Topic #	Description	Learning Activities	Tentative timeline	
1: Introduction	 Introduction to Python and data science Supervised, unsupervised, semi-supervised learning 	 Powerpoint lectures Tutorial 1: "hello world" in Python Zoom office hours Assignment 1 	Week 1	
2: Definitions	 Notation Baye's rule Hyperparameters Classification vs regression 	 Powerpoint lectures Tutorial 2: Numpy, Scikit-learn, Pytorch packages Zoom office hours Assignment 1 	Week 2	
3: "Classical" learning algorithms	 Logistic regression Decision trees Support vector machines Nearest neighbours 	 Powerpoint lectures Zoom office hours Assignment 2	Week 3	
4: "Learning" algorithms	 Gradient descent Loss function Overfitting vs underfitting Training vs testing vs validation Missing features 	Powerpoint lecturesZoom office hoursAssignment 2	Week 4	
5: Feature engineering	 Normalization Binning One-hot encoding Performance metrics Validation 	Powerpoint lecturesZoom office hoursAssignment 3	Week 5	
6: Deep learning	Neural networksBack propagation	Powerpoint lecturesZoom office hoursAssignment 3	Week 6	
7: Flavours of deep learning	 Convolutional neural networks Recurrent neural networks 	 Powerpoint lectures Zoom office hours Assignment 4 	Week 7	
9. Concretional	Fall reading week – n	o class	Waalr 0	
adversarial networks	- Discriminative vs. Generative Modeling - Conditional GANs	 Powerpoint lectures Zoom office hours Assignment 4 	WEEK 9	
9: Unsupervised learning	- K-means - PCA - ICA	 Powerpoint lectures Zoom office hours Term project 	Week 10	
En	d of lectures to allow students m	nore time for project		
Pro	esentation and reports due for pi	roject at end of term		

POTENTIAL PROJECT TOPICS

The following are possible project ideas, but students are also encouraged to develop their own ideas following their interests.

Project option 1:

Time series prediction with MLRA data (series of pore pressure sensors). The students will attempt to predict the pore pressure in these sensors using air temperature, rainfall, and air pressure. Could be done using decision tree or RNN.

Project option 2:

Image classification of cracked vs uncracked rocks. Likely requires CNN, data will come from MIT rock mechanics research group high-speed data. The students will be provided with high-speed video images of a rock undergoing fracturing from uniaxial loading, students will develop a classifier for whether there is a crack on the rock. Students will additionally attempt to label the regions corresponding to cracked rock.

General Learning Objectives:

E=Evaluate, T=Teach, I=Introduce; (I) = Intoduction, (D) = Developing, (A) = Advanced level

Knowledge Base	E (I)	Engineering Tools	Т	Impact on Society	
Problem Analysis	Т	Team Work	Т	Ethics and Equity	
Investigation	Т	Communication	Т	Economics and Project Management	
Design		Professionalism		Life-Long Learning	Т

<u>Course Breakdown:</u> (Values given in accreditation units) Engineering Science = 100%

Evaluation:

The final mark will be determined as follows:

Assessment	Tentative Due Date	Weight
Assignment 1	6 th October	5%
Assignment 2	20 th October	15%
Assignment 3	10 th November	15%
Assignment 4	24 th November	15%
Project 2 documentation of code and dataset	8 th December	25%
Project 2 presentation	8 th December	25%

Note: Students must pass the final project to pass this course. Students who fail the final examination will be assigned the aggregate mark, as determined above, or 48%, whichever is less. Students who have failed this course previously must repeat all components of the course. No special permissions will be granted enabling a student to retain laboratory, assignment or test marks from previous years. Previously completed assignments and laboratories cannot be resubmitted.

1. Class projects:

Code and presentations will be submitted on specified date. Presentations will occur the following week. Extensions are to be negotiated with the course instructor, not the teaching assistants.

2. Use of English:

In accordance with Senate and Faculty Policy, students may be penalized up to 10% of the marks on all assignments, tests, and examinations for improper use of English. Additionally, poorly written work with the exception of the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

Cheating:

University policy states that cheating is a scholastic offence. The commission of a scholastic offence is attended by academic penalties that might include expulsion from the program. If you are caught cheating, there will be no second warning.

For more information on scholastic offenses, please see: http://www.uwo.ca/univsec/handbook/appeals/scholastic discipline undergrad.pdf

Attendance:

Any student who, in the opinion of the instructor, is absent too frequently from class, laboratory, or tutorial periods will be reported to the Dean (after due warning has been given). On the recommendation of the Department concerned, and with the permission of the Dean, the student will be debarred from taking the regular final examination in the course.

Conduct:

Students are expected to arrive at lectures on time, and to conduct themselves during class in a professional and respectful manner that is not disruptive to others. Please turn off your cell phone before coming to a class, tutorial, quiz or exam. On the premises of the University or at a University-sponsored program, students must abide by the Student Code of Conduct: <u>http://www.uwo.ca/univsec/board/code.pdf</u>



Western University - Faculty of Engineering 2023-2024

STATEMENT ON GENDER-BASED AND SEXUAL VIOLENCE

Western is committed to reducing incidents of gender-based and sexual violence and providing compassionate support to anyone who has gone through these traumatic events. If you have experienced gender-based or sexual violence (either recently or in the past), you will find information about support services for survivors, including emergency contacts, <u>here</u>. To connect with a case manager or set up an appointment, please contact <u>support@uwo.ca</u>.

INSTRUCTIONS FOR STUDENTS UNABLE TO WRITE TESTS OR EXAMINATIONS OR SUBMIT ASSIGNMENTS AS SCHEDULED

If, on medical or compassionate grounds, you are unable to write term tests or final examinations or complete course work by the due date, you should follow the instructions listed below. You should understand that academic relief will not be granted automatically on request. You must demonstrate to your department (or the Undergraduate Services Office) that there are compelling medical or compassionate grounds that can be documented before academic relief will be considered. Different regulations apply to term tests, final examinations and late assignments. Please read the instructions carefully.

A. <u>GENERAL REGULATIONS & PROCEDURES</u>

- 1. All first-year students will report to the Undergraduate Services Office by submitting the <u>Academic Consideration Request</u> <u>Form</u>, for all instances.
- If you are an upper year student and you are missing a test/assignment/lab or examination you will report the absence by submitting <u>Academic Consideration Request Form</u>. Absences worth LESS THAN 10% of your mark, will be processed by your department office. If your course work is worth 10% OR MORE of your final grade, your request will be processed by the Undergraduate Services Office.
- 3. Check the course outline to see if the instructor has a policy for missed tests, examinations, late assignments or attendance.
- 4. Documentation must be provided as soon as possible. If no one is available in your department office or the Undergraduate Services Office, leave a message <u>clearly</u> stating your name & student number and reason for your call. The department telephone numbers are given at the end of these instructions.
- 5. If you decide to write a test or an examination you should be prepared to accept the mark you earn. Rewriting tests or examinations or having the value of a test or examination reweighted on a retroactive basis is not permitted.

B. <u>TERM/MIDTERM TESTS</u>

- 1. If you are in first year and you are unable to write a midterm/term test, contact the Undergraduate Services Office, SEB 2097 <u>PRIOR</u> to the scheduled date of the test.
- 2. If you are an upper year student and you are unable to write a midterm/term test, inform your instructor <u>PRIOR</u> to the scheduled date of the test and request relief through the <u>Academic Consideration Request Form</u>. If the instructor is not available, leave a message for him/her at the department office. If the test is worth LESS THAN 10% of your mark, your request for relief will be processed by your department office. If the test is worth MORE THAN 10% of your final grade your request for relief will be processed by the Undergraduate Services Office.
- 3. Be prepared to attach supporting documentation to the Department Chair and/or the Undergraduate Services Office through the online form (see next page for information on documentation).

4. Discuss with the instructor if and when the test can be rescheduled. The approval of the Chair or the Undergraduate Services Office is required when rescheduling midterm/term tests.

C. FINAL EXAMINATIONS

- If you are unable to write a final examination, contact the Undergraduate Services Office PRIOR TO THE SCHEDULED EXAMINATION TIME to report your absence using the <u>Academic Consideration Request Form</u> and request permission to write a Special Final Examination. If no one is available in the Undergraduate Services Office, leave a message <u>clearly</u> stating your name & student number.
- 2. Be prepared to provide the Undergraduate Services Office with supporting documentation (see next page for information on documentation) the next day, or as soon as possible (in cases where students are hospitalized). The following circumstances are not considered grounds for missing a final examination or requesting special examinations: common cold, headache, sleeping in, misreading timetable and travel arrangements.
- 3. In order to receive permission to write a Special Examination, you <u>must</u> obtain the approval of the Chair of the Department **and** the Associate Dean and in order to apply you <u>must</u> submit an "<u>Application for a Special Exam</u>" form. The Undergraduate Services Office will then notify the course instructor(s) and reschedule the examination on your behalf.

PLEASE NOTE: It is the student's responsibility to check the date, time and location of the Special Examination.

D. <u>LATE ASSIGNMENTS</u>

- 1. Advise the instructor if you are having problems completing the assignment on time (prior to the due date of the assignment).
- 2. Be prepared to submit the <u>Academic Consideration Request Form</u> and provide documentation if requested by the instructor (see reverse side for information on documentation).
- 3. If you are granted an extension, establish a due date. The approval of the Chair of your Department (or the Assistant Dean, First Year Studies, if you are in first year) is not required if assignments will be completed prior to the last day of classes.
- 4. i) Extensions beyond the end of classes must have the consent of the instructor, the department Chair and the Associate Dean, Undergraduate Studies. Documentation is mandatory.
 - A Recommendation of Incomplete Form must be filled out indicating the work to be completed and the date by which it is due. This form must be signed by the student, the instructor, the department Chair and the Associate Dean, Undergraduate Studies.

E. <u>SHORT ABSENCES</u>

If you miss a class due to a minor illness or other problem, check your course outlines for information regarding attendance requirements and make sure you are not missing a test, laboratory or assignment. Cover any readings and arrange to borrow notes from a classmate.

F. <u>EXTENDED ABSENCES</u>

If you are absent more than one week or if you get too far behind to catch up, you should consider reducing your workload by dropping one or more courses. (Note drop deadlines listed below). You are strongly encouraged to seek advice from your Academic Counsellor in the Undergraduate Services Office.

G. <u>DOCUMENTATION</u>

If you consulted an off-campus doctor or Student Health Services regarding your illness or personal problem, you <u>must</u> provide the doctor with a Student Medical Certificate to complete at the time of your visit and then bring it to the Department (or the Undergraduate Services Office). This note must contain the following information: severity of illness, effect on academic studies and duration of absence. Regular doctor's notes will not be accepted; only the Student Medical Certificate will be accepted.

<u>In Case of Serious Illness of a Family Member</u>: Provide a Student Medical Certificate to your family member's physician to complete and bring it to the Department (or the Undergraduate Services Office if you are in first year).

In Case of a Death: Obtain a copy of the death certificate or the notice provided by the funeral director's office. You must include your relationship to the deceased and bring it to the Department (or the Undergraduate Services Office if you are in first year).

For Other Extenuating Circumstances: If you are not sure what documentation to provide, ask the Departmental Office (or the Undergraduate Services Office if you are in first year) for direction.

Note: Forged notes and certificates will be dealt with severely. To submit a forged document is a scholastic offence (see below).

H. <u>ACADEMIC CONCERNS</u>

Integrated Engineering

Mechanical Engineering:

- 1. You need to know if your instructors have a policy on late penalties, missed tests, etc. This information may be included on the course outlines. If not, ask your instructor(s).
- 2. You should also be aware of attendance requirements in some courses. You can be debarred from writing the final examination if your attendance is not satisfactory.
- 3. If you are in academic difficulty, check out the minimum requirements for progression in the calendar. If in doubt, see your Academic Counsellor.

Calendar References: Check these regulations in your 2023 Western Academic Calendar available at www.westerncalendar.uwo.ca.

Absences Due to Illness:

https://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_13

Academic Accommodations for Students with Disabilities:

http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_10
Academic Accommodations for Religious or Holy Days:

http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_16 Course Withdrawals:

http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=6&SelectedCalendar=Live&ArchiveID=#Page_75 Examinations:

<u>http://www.westerncalendar.uwo.ca/PolicyPages.cfm?PolicyCategoryID=5&command=showCategory&SelectedCalendar=Live&ArchiveID</u>=
Scheduling of Term Assignments:

http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=5&SelectedCalendar=Live&ArchiveID=#SubHeading_78 Scholastic Offences:

http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=1&SelectedCalendar=Live&ArchiveID=#Page_20 Student Medical Certificate:

https://www.eng.uwo.ca/files/undergraduate/student-medical-certificate.pdf

Engineering Academic Regulations:

http://www.westerncalendar.uwo.ca/PolicyPages.cfm?Command=showCategory&PolicyCategoryID=4&SelectedCalendar=Live&ArchiveID=#Page_86

Note: These instructions apply to all students registered in the Faculty of Engineering regardless of whether the courses are offered by the Faculty of Engineering or other faculties in the University.

<u>Add Deadlines:</u>	First term half course (i.e. "A" or "F") Full courses and full-year half course (i Second term half course (i.e. "B" or "G	i.e. "E", "Y" ('")	or no suffix)	September 15, 2023 September 15, 2023 January 16, 2024
<u>Drop Deadlines</u> :	First term half course without penalty (i.e. "A" or "F") Full courses and full-year half courses without penalty (i.e. "E", "Y" or no suffix) Second term half or second term full course without penalty (i.e. "B" or "G")			November 13, 2023 fix) November 30, 2023 March 7, 2024
Contact Information:				
Undergraduate Services	Office:	SEB 2097	Phone: 519-661-2130	E-mail: engugrad@uwo.ca
Chemical & Green Proce	ess Engineering:	TEB 477	Phone: 519-661-2131	E-mail: cbeugrad@uwo.ca
Civil Engineering:		SEB 3005	Phone: 519-661-2139	E-mail: civil@uwo.ca
Computer, Electrical, Mechatronic Systems & Software Engineering		TEB 279	Phone: 519-661-3758	E-mail: eccugrad@uwo.ca

ACEB 2410Phone: 519-661-6725

SEB 3002 Phone: 519-661-4122

E-mail: engceli@uwo.ca

E-mail: mmeundergraduate@uwo.ca